Longitudinal Tracking of Adolescent Smoking, Physical Activity, and Food Choice Behaviors

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ABSTRACT

Objectives. A major assumption underlying youth health promotion has been that physiological risk factors track from childhood into adulthood. However, few studies have systematically examined how behaviors change during adolescence. This paper describes longitudinal tracking of adolescent health behaviors in two Minnesota Heart Health Program communities.

Methods. Beginning in sixth grade (1983), seven annual waves of behavioral measurements were taken from both communities (baseline n = 2376). Self-reported data included smoking behavior, physical activity, and food preferences.

Results. A progressive increase in the change to weekly smoking status was observed across the smoking status categories. As students began to experiment with smoking, they were more likely to either begin to be or remain regular smokers. Tracking of physical activity and food choice variables was also apparent. In nearly all the follow-up periods, the students identified at baseline as measuring high remained high, and those measuring low remained low.

Conclusions. These results indicate that there is evidence of early consolidation and tracking of physical activity, food preference, and smoking behavior. The early consolidation of health behaviors implies that interventions should begin prior to sixth grade, before behavioral patterns are resistant to change. The smoking results suggest that students are experiencing difficulty quitting smoking; thus, youth smoking cessation interventions are warranted. (*Am J Public Health.* 1994;84:1121–1126)

Introduction

Efforts directed toward the primary prevention of cardiovascular disease in youth populations have typically focused on the modification of health behaviors such as physical activity, dietary intake, and cigarette smoking. The major assumptions for the rationale behind youth health promotion have been that (1) a certain proportion of children and adolescents are at excess physiological and behavioral risk; (2) physiological risk factors track from childhood into adulthood; (3) the development of physiological risk factors depends largely on the initiation of health-compromising behaviors (such as poor eating and physical activity habits, and cigarette smoking); and (4) primary prevention can be achieved through the modification of behaviors known to be related to physiological risk factors before behavioral patterns are more fully established and resistant to change.[1,2]

Many studies have provided evidence substantiating these assumptions. The relationship between dietary intake, physical activity, cigarette smoking, and cardiovascular disease for adults is well known.[3,4] There is early physiological evidence of cardiovascular disease where fatty streaks and atheromatous changes have been found in the aortas and coronary vessels of children and young adults dying of unrelated disease and war injuries.[5,6] During the past decade there have been six major studies tracking physiological risk factors for cardiovascular disease in childhood, and these studies have each indicated that total, low-density, and high-density lipoprotein cholesterol measurements in childhood and adolescence are predictive of adult values.[7–13] The onset of smoking begins with initial favorable attitudes toward smoking, and as youth move through middle and high school, a substantial proportion progress from initiation to occasional smoking and on to regular nicotine-dependent smoking.[14,15] Few individuals initiate smoking past high school.[16] Finally, several primary prevention studies have investigated various youth health promotion strategies and found encouraging results.[17]

Few studies have systematically examined how cardiovascular disease–related behaviors change during childhood and adolescence within a cohort of youth. If youth health behaviors track during childhood and adolescence, it would add support to the primary assumptions given for early interventions to prevent cardiovascular disease. For this paper, tracking is defined as the stability of health behaviors over time, or the maintenance of relative position in rank of behavior over time.

Methods

Research Design

The Class of 1989 Study annually measured a cohort of students from 6th to

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This paper was accepted February 1, 1994.

Editor's Note. See related editorial by Shelov (p 1066) in this issue.

TABLE 1—Percentage of Students Who Became Weekly Smokers over 1 Year

Grade Change	Never Smoker Becoming Weekly Smoker		Experimenter Becoming Weekly Smoker		Quitter Becoming Weekly Smoker		Weekly Smoker Remaining Weekly Smoker	
	No.	%	No.	%	No.	%	No.	%
Reference community								
6th to 7th	600	3.3	254	13.5	23	34.8	24	49.7
7th to 8th	494	4.1	263	15.3	50	31.9	54	64.6
8th to 9th	344	2.8	259	7.6	61	22.7	83	62.0
9th to 10th	258	3.0	285	16.2	60	45.6	97	54.1
10th to 11th	219	2.7	269	9.3	47	38.2	106	80.0
11th to 12th	131	2.2	148	9.2	22	32.5	62	92.2
Intervention community								
6th to 7th	842	1.1	318	5.1	23	13.0	15	12.0
7th to 8th	709	1.6	422	5.8	45	20.1	35	56.8
8th to 9th	595	2.9	375	11.7	47	22.3	39	60.6
9th to 10th	433	2.1	388	9.4	41	26.3	111	45.5
10th to 11th	388	0.6	375	7.9	71	37.5	88	77.8
11th to 12th	299	2.3	337	8.0	52	21.4	97	79.9

Note. Each cell represents that column's percentage of change to weekly smoker over a 1-year interval. For example, 13.5% of experimental smokers in the reference community became weekly smokers between sixth and seventh grades.

12th grade on a variety of health behaviors. The study was designed to test the efficacy of a school-based cardiovascular disease prevention program embedded in the Minnesota Heart Health Program community campaign to reduce heart disease.[1,18] The research design, interventions, and main outcomes of the study have been described elsewhere.[1,18–22]

Two of the six communities in the Minnesota program were involved in the Class of 1989 Study. All sixth graders enrolled in the public schools in both communities were invited to participate in a baseline survey in April 1983, and that grade cohort was surveyed annually in April until their graduation from high school in 1989. The students in the intervention community participated in 5 years of Minnesota Heart Health Program–sponsored behavioral health programs in school from 6th through 10th grade and also were exposed to the Minnesota program community interventions. The intervention results indicate positive community and school intervention effects on youth smoking, physical activity, and food choice behaviors.

Outcome Evaluation

The measures for cigarette smoking each year included standardized self-reported items.[19,23] Two variables were used: weekly smoking prevalence and a multilevel categorical variable of never smoker, experimental smoker, quitter, and weekly smoker. The measures for physical activity each year were self-reported hours of exercise per week and a physical activity score.[20,24] For these analyses, hours of exercise per week was also divided into four categories: less than 1 hour, 2 to 3 hours, 4 to 5 hours, and greater than 6 hours per week. In the physical activity score, which measured frequency and intensity of regular physical activity, each unit increase means greater frequency and intensity of physical activity. For these analyses, the physical activity score was also divided into tertiles. The measure for dietary intake was self-reported food preferences.[21,24] Students were asked to select from 18 food pairs the "one food they would usually eat when they had the choice"; a unit increase means one more healthier food choice. For these analyses, the food choice score was divided into quintiles.

Analysis Methods

The tracking analyses were accomplished for the physical activity and food choice variables by dividing baseline values into categories (quintiles or tertiles) and computing the subsequent mean values for students originally within those categories. If a mean value within any sixth-grade category maintained a relative position in rank compared with that in the other categories, this was interpreted as evidence of tracking. Using PROC GLM in SAS,[25] a model was fit for each year of follow-up (7th to 12th grades) on the three behavioral physical activity and food choice dependent variables. These analyses were stratified by sex and intervention community, and were adjusted for age, sex, and, in the later years of measurement, school and parental occupation (1986 to 1989 for school; 1987 to 1989 for parental occupation).

This type of tracking analysis is meant to be descriptive; evidence of tracking should be observed by plotting the mean values within sixth-grade categories across time. An additional analysis was performed to determine any differential trends within those categories across time. Using PROC GLM repeated measures in SAS,[25] a model was fit that included a sixth-grade category by time interaction. This analysis approach was used to determine the mean change within categories from 7th to 11th grade on the dependent variable. In this case, a nonsignificant result indicates an equal amount of change within each category and would support the tracking hypothesis. Eleventh grade was selected to assess the change over time in preference to 12th grade because of extensive attrition in 12th grade, particularly in the reference community.

A different analytic approach was taken to assess tracking of cigarette smoking behavior. Because few students are smoking in 6th grade and rapid yearly onset is expected up to 10th grade, the change in smoking status from one year to the next was examined. Using the four-level smoking status variable, the change over a year to weekly smoking from each of the four smoking categories—that is, the proportion of students changing from never smoker, experimental smoker, or quitter to weekly smoker; and those students remaining a weekly smoker (over the year)—was calculated. Again, these analyses were meant to be descriptive, and no statistical testing strategy was used.

Results

Tracking of Smoking Behavior

Table 1 presents data for the adjusted change to weekly smoking from year to year within each of the four smoking categories for both the reference and intervention communities. Significant intervention effects have been reported elsewhere, so these results have been stratified by intervention condition.[19] In

the reference community, the shift from never to weekly smoker from sixth to seventh grade was 3.3%; from seventh to eighth grade, 4.1% of never smokers became weekly smokers, and so on. Likewise, the shift from sixth to seventh grade from experimental smoker to weekly smoker was 13.5%.

A consistent pattern in the change to weekly smoking status can be seen in Table 1 across the smoking status categories. These data indicate a stable and consistent multistage pattern of onset, in which fewer students move from never to weekly smoking than move from never smoking to experimenting, quitting, or remaining weekly smokers. The results are striking for the column of weekly smokers remaining weekly smokers, which indicates that students who smoke are increasingly unlikely to quit as they get older. This observation is corroborated by the quitter column, in which a large proportion of students return to weekly smoking after reporting having quit smoking.

Noticeable differences were observed between the reference and intervention communities, particularly from sixth to seventh and from seventh to eighth grades, where the school smoking intervention occurred. In both of these rows, the change to weekly smoking was lower in the intervention community. In addition, nearly all the cells on the intervention half of the table have a lower weekly smoking prevalence compared with the reference half, some by 10% or more.

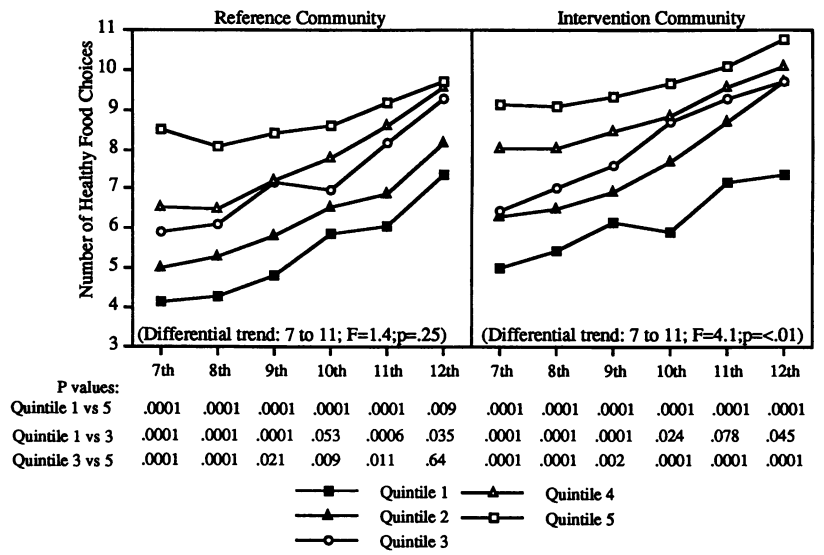

FIGURE 1—Tracking of healthy food choices: females.

Tracking of Healthy Food Choices

Figure 1 presents tracking of healthy food choices for females by reference and intervention communities. Significant intervention effects by sex have been reported elsewhere, so results have been stratified by intervention condition and sex.[21] The mean number of healthy food choices was calculated and plotted from 7th to 12th grade within the 6th-grade categories of students. If food choices track, the cohort of 6th-graders' values would be expected to remain separate and distinct over time; if the behavior does not track, the lines would be expected to cross and overlap over time. The bottom portion of Figure 1 includes data on differential trend; this refers to the mean change from 7th to 11th grade within the 6th-grade categories. A nonsignificant test for differential trend is interpreted as no difference in the repeated measures change by 6th-grade category from 7th to 11th grade. Thus, a nonsignificant result supports the tracking hypothesis; a significant differential trend would indicate that at least one category has changed compared with the others over time.

In 6th grade, the healthy food choice variable was divided into quintiles, and the mean number of choices was calculated within those quintiles and plotted from 7th to 12th grade. In Figure 1, a noticeable parallel separation between the groups was observed that visually supports behavioral tracking; that is, sixth-grade rankings of healthy food choices are likely to maintain over time. In sixth grade, at all follow-up periods, those in quintile 1 were significantly different from quintile 5, quintiles 1 and 3 were significantly different at 10 of 12 follow-up periods, and quintiles 3 and 5 were significantly different at 11 of 12 follow-up periods. Additional corroborating evidence is offered by the nonsignificant tests for differential trend in the reference community. A significant differential trend was observed in the intervention community as the increase in the lower two quintiles surpassed that of the upper three, a finding not unexpected since significant intervention effects were observed (reported elsewhere).[21] Similar results were observed for males in that all 12 comparisons between quintiles 1 and 5 and between quintiles 3 and 5 were significant, as were 11 of 12 comparisons between quintiles 1 and 3. Both differential tests for trend were nonsignificant.

Tracking of Activity Score and Hours of Exercise per Week

Figure 2 presents tracking of the activity score (frequency and intensity of physical activity) for sixth-grade females by reference and intervention communities. In these figures, the activity score was divided into tertiles, where tertile 1 represents the least physically active third of the distribution.

A clearly defined pattern of tracking can be observed across the grades. With the exception of one follow-up period, tertile 1 was significantly different from tertile 3. Both tests for differential trend were nonsignificant, corroborating the visual tracking result. The intervention effects of the Class of 1989 Study are also discernible in Figure 2, where the lowest tertile for females appears to have been influenced to a greater extent than tertile 3. This pattern was not unexpected because there were significant intervention effects (reported elsewhere).[20] Similar results were observed for males in that 10 of 12 comparisons between tertiles 1 and 3 were significant, and a significant differential test for trend was observed in the intervention community.

Figure 3 presents tracking of hours of exercise per week for females by reference and intervention communities. Significant intervention effects by sex have been reported elsewhere, so results have

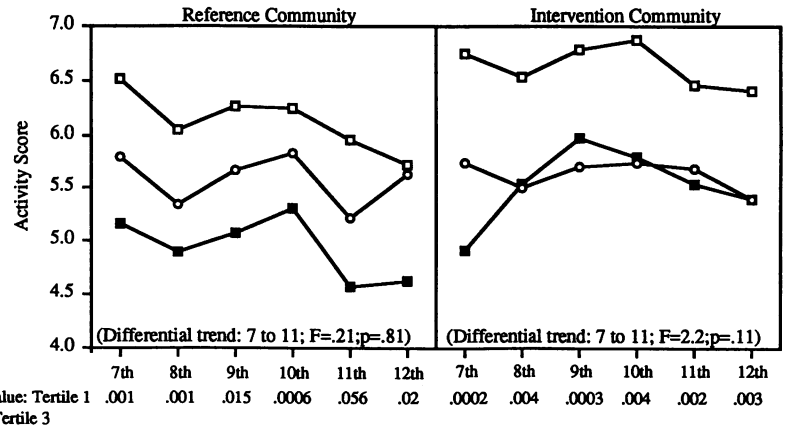

FIGURE 2—Tracking of activity score: females.

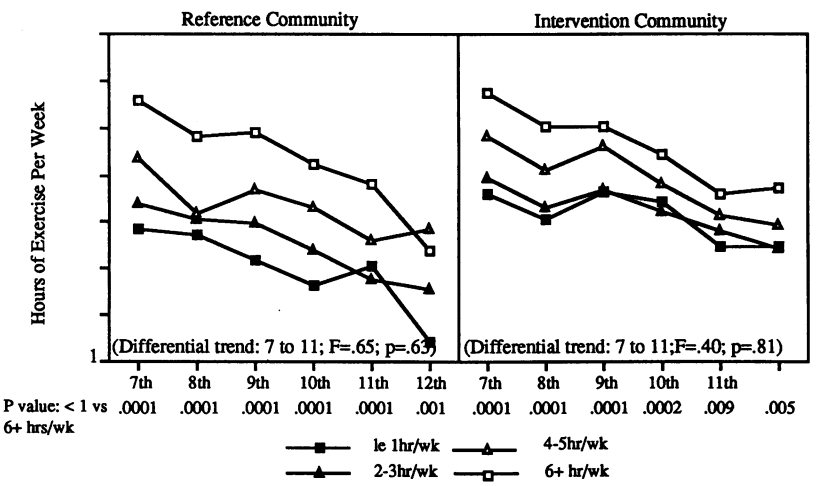

FIGURE 3—Tracking of hours of exercise per week: females.

been stratified by intervention condition and sex.[20] Here again, a clear pattern of tracking can be observed. This observation is most apparent when comparing the highest (6+) with the lowest (<1) groups of exercisers; at each follow-up period, these groups were significantly different. This finding is corroborated by the nonsignificant test for trend in both communities. Similar results were observed for males in that all 12 comparisons between high and low groups were significant, and a significant differential test for trend was observed in the intervention community.

Attrition Analysis

Financial constraints precluded any attempt to contact those students who were not present in class the day of the survey. Response rates for the entire sample for the six follow-up periods were 88%, 81%, 70%, 66%, 59%, and 45% (n's at baseline: intervention = 1342; reference = 1034). These response rates were approximately equal by community with the exception of the last year of data collection, when 55% of the intervention community students were resurveyed compared with 31% of the reference community. Students who were not measured at one survey typically displayed mean values on prior surveys that were less healthy than those of students who were present at more measurement periods.[19–21] Differential attrition bias has been explored and response rates within these categories were nearly equivalent, indicating little if any attrition bias.

Discussion

The concept of behavioral tracking refers to the maintenance of relative ranking of students over time on a given health behavior. These results support the hypothesis that the cardiovascular disease–related behaviors measured in the Class of 1989 Study tracked from 6th to 12th grade. A progressive increase in the change to weekly smoking status was observed across the smoking status categories. A stable and consistent multistage pattern of smoking onset was observed in which fewer students moved to weekly smoking from never smoking than moved from experimenting, quitting, or remaining weekly smokers. Figures 1 through 3, which show the tracking data for the physical activity and food choice variables, all offer visual evidence of tracking. In nearly all the follow-up periods, the students identified in sixth grade as measuring high on any variable remained high, and those measuring low remained low.

These data indicate a clear pattern of tracking and may be interpreted as support for one of the assumptions underlying the rationale for youth health promotion. If students separate at an early age into high- and low-risk groups and maintain their relative ranking over time, presumably into adulthood, then interventions to alter the risk at or before the age of separation are warranted. In addition, these results, coupled with results previously published from these data that indicate a significant amount of covariation among these behaviors,[26] provide evidence that early intervention across multiple risk behaviors is appropriate.

The tracking information not only provides justification for interventions targeting adolescents and younger children, but also may be of assistance to improve the content of future health promotion interventions. A striking pattern of data observed for smoking tracking suggests that once students become weekly smokers, they are unlikely to give up cigarettes. Of the students who were current smokers, an increasing percentage remained smokers over the years of follow-up; they were either unable or unwilling to quit smoking. Of the self-reported quitters, 13% to 46% returned to weekly smoking by the next year's measurement period. Both these observations suggest that nicotine addiction begins early in the students' use of tobacco. From an intervention perspective, these data clearly warrant continued smoking

prevention efforts as well as smoking cessation interventions among high school–aged students. Yet research on the effectiveness of smoking cessation interventions in this age group has not been extensive or encouraging.[27] On the other hand, for the students who self-report having made the effort to quit smoking, 64% to 87% were able to remain a nonsmoker over a year, a rate higher than that reported in most professionally led adult smoking cessation interventions.[28] These higher than expected rates of quitting may be owing to classification error where we cannot be certain of the students' level of involvement with tobacco prior to quitting. Nevertheless, if students who make the effort to quit smoking are relatively successful, encouraging greater numbers of teenage smokers to contemplate or self-initiate quitting may be a useful strategy in combination with smoking prevention programs.

The tracking data for physical activity and healthy food choices offer convincing evidence in support of tracking from 6th to 12th grade. The upward or downward trends across the variables indicate that students are indeed changing their behaviors over time but that the change is relative to the behavior of their peers. This persistence in rankings suggests that consolidation of these health behaviors may begin prior to sixth grade and that interventions in early grade school are warranted. The observation that groups maintain relative ranking indicates that there are subgroups of students who remain at higher risk than their peers. These higher risk groups may require additional intervention to improve their risk profile. Interestingly, the significant tests for differential trend in the intervention community were largely owing to positive changes among those at highest risk. This suggests that the intervention program appears to have had a larger effect among those who needed it most.

Although data from the Class of 1989 Study provide information about patterns of tracking, the limitations must be considered. One possible source of bias for interpretation of the eating and physical activity–related tracking results pertains to measurement. First, the measurement instruments were designed to detect intervention impact and are appropriate for determining differences in group means, but they do not reflect actual nutritional intake and may not accurately reflect true levels of physical activity. There are many difficulties inherent in measuring nutrition and physical activity levels, especially in youth populations.[29] For example, it is clear that healthy food choices are tracking over time, but it is unclear how much these variables relate to actual fat, salt, and carbohydrate consumption. Self-reported measures are subject to demand characteristics such as social desirability or repeated testing that introduces additional within- or between-person variation. The additional variation caused by measurement error, however, would reduce the chances of detecting tracking. Second, self-reported smoking data were not verified with objective biochemical measurements, and these data do not include students who have dropped out of school, a group known to have high rates of smoking.[30] Thus, the smoking rates presented probably underestimate smoking prevalence among adolescents.

The results from the Class of 1989 tracking analysis indicate that there is evidence of early consolidation and tracking of physical activity, food choice, and smoking behaviors. The results have implications for the assumptions underlying school health promotion. First, the early consolidation of health behaviors implies that interventions should begin prior to sixth grade, before the behavioral patterns become more difficult to change. If the tracking of health behaviors is found to be a general phenomenon, it is possible that interventions designed for younger students may move the entire student distribution toward healthier behavioral practices and further improve the impact of interventions at later grades. Future research should replicate these results, beginning with a younger sample of students.

Second, the smoking results indicate that smoking students are addicted to tobacco and are in need of smoking cessation interventions. This appears to be a fertile area of investigation as very few studies have been published on youth smoking cessation programs. In addition, smoking cessation may be facilitated by inserting cessation messages into existing smoking prevention programs, especially in 9th and 10th grades, when the prevalence of smoking warrants greater cessation efforts. □

Acknowledgments

This research was supported by the National Heart, Lung, and Blood Institute, grant RO1-HL 25523.

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Planning the 1997 National Health and Nutrition Examination Survey

The National Center for Health Statistics, Centers for Disease Control and Prevention, is soliciting suggestions for topics to be considered in the planning process for the next National Health and Nutrition Examination Survey (NHANES), scheduled for 1997. As in previous NHANES, the primary purpose will be to measure and monitor the health and nutritional status of the US population.

Please send all research suggestions by *October 1, 1994.* Submit specific recommendations, including brief descriptions of the suggestion's public health importance and the available data collection methodologies, to Vicki Burt, Chief, Survey Planning and Development Branch, Division of Health Examination Statistics, National Center for Health Statistics, Presidential Building, Rm 1000, 6525 Belcrest Rd, Hyattsville, MD 20782.